REPORTS OF OBSERVATORIES.[1]

CHAMBERLIN OBSERVATORY, DENVER, COLORADO.

During the year 1908 Mr. SHELTON SWAN and the Director devoted all the time that could be spared from other duties to comet and asteroid observations. Miss MYRTLE RICHMOND, a graduate student in the University of Denver, devoted much time to the reduction of observations, which are now ready for publication.

HERBERT A. HOWE, *Director.*

INTERNATIONAL LATITUDE OBSERVATORY, UKIAH, CALIFORNIA.

Regular observation for the variation of latitude was continued throughout the year 1908. The observing program was that used in 1906 and 1907; assigned by the International Geodetic Association for the period of four years following 1906.0.

The continuity of the work was satisfactory, but was somewhat interrupted in the summer by the heated air and smoke from the most serious brush fires that have visited the immediate vicinity of the observatory since its establishment.

Subsidiary observations and reductions made from time to time indicated uniformly excellent stability of the instrument and constancy of its factors, and entirely satisfactory observational results.

JAMES D. MADDRILL,
Astronomer-in-Charge.

LICK OBSERVATORY, MOUNT HAMILTON, CALIFORNIA.

Inasmuch as the Director's reports to the President of the University of California date from July 1st, the beginning of the academic year, the annual reports appearing in these *Publications* will be for the twelve months beginning with July 1st, save that the series will be inaugurated by a report covering the period January 1, 1908, to July 1, 1909. This report will appear in the number for August.

W. W. CAMPBELL, *Director.*

[1] Arranged alphabetically according to name.

NAVAL OBSERVATORY, MARE ISLAND, CALIFORNIA.

The work of this observatory during the past year has continued about the same as in former years. The usual number of chronometers has been rated and issued to ships in the naval service and the time service has been maintained as heretofore. By courtesy of the Director of the Lick Observatory, in connection with the co-operation of the Bureau of Equipment, the longitude of the observatory was redetermined in May, 1908, by Professor R. H. TUCKER and Mr. SANFORD from Mount Hamilton. The new seismograph of the Bosch-Omori type, recently purchased, is being mounted in a suitable room, on heavy solid foundations, and it is believed that it will give very satisfactory records of earthquakes. The officer in charge of the observatory has been able to bring to a successful conclusion certain researches on the origin of the solar system, with which he has been occupied for many years. A preliminary report of this work has been printed in the *Publications* of the Astronomical Society of the Pacific, No. 126, and in the *Astronomische Nachrichten,* No. 4308.

T. J. J. SEE,
Professor of Mathematics, U. S. Navy, in Charge.

SOLAR OBSERVATORY, MOUNT WILSON, CALIFORNIA.

The continuation and extension of the researches described in my last annual report have led to the following results:—

(1) The comparative study of the spectra of the limb and center of the Sun favors the conclusion that the relative displacements of the lines near the limb (after eliminating the Doppler effect) are mainly due to pressure. Further laboratory work is required before a final decision can be reached.

(2) The angular velocity of the solar rotation, as determined from the motions of the calcium (H_2) flocculi on the spectroheliograph plates, decreases from the equator toward the poles. The mean velocity at any latitude is very nearly the same as that of the sun-spots.

(3) The angular velocity of the solar rotation, as determined from the motion in the line of sight of the hydrogen represented by dark lines in the solar spectrum, is more rapid at the equator than the angular velocity of the spots and calcium (H_2) flocculi, and decreases less rapidly toward the poles.

(4) The hydrogen ($H\delta$) flocculi, as measured on spectroheliograph plates, move at the equator with about the same angular velocity as the calcium (H_2) flocculi, and show no evidence of retardation toward the poles. This result was obtained before the discovery of solar vortices, and must be tested by measurements of the motions of $H\alpha$ flocculi lying outside of the vortices.

(5) Investigations with an electric furnace have shown that such changes of relative intensity as are exhibited by the lines of iron, titanium, and other substances in sun-spots are produced by lowering the temperature of the furnace. This is in harmony with our conclusion that the temperature of these vapors in sun-spots is lower than in the reversing layer outside of spots.

(6) The flutings of calcium hydride, as observed in another form of electric furnace, have been identified with flutings in our photographs of sun-spot spectra.

(7) Through the use of the $H\alpha$ line of hydrogen, it has become possible to photograph a hitherto unexplored region of the solar atmosphere. The photographs show that sun-spots are surrounded, and perhaps produced, by extensive vortices.

(8) The components of double lines photographed in the spectra of sun-spots with the 30-foot spectrograph of the tower telescope have been found to be circularly polarized in opposite directions. This and much other evidence proves that sun-spots contain a strong magnetic field. By means of spectrographic observations the areas, strengths, and polarities of these fields can be measured, thus permitting a magnetic survey of the entire visible hemisphere of the sun to be made.

In addition to these investigations, much work of research described in other parts of this report has been done, and the work of construction has advanced very satisfactorily. A spectroscopic laboratory in Pasadena, equipped for investigations requiring very high temperatures and pressures, was completed and occupied in March. The 60-inch reflector has been erected.

STAFF.

Mr. W. S. ADAMS has continued his work as superintendent of the computing division, and Mr. G. W. RITCHEY has had

charge of construction, both in Pasadena and on Mount Wilson. Dr. ARTHUR S. KING, formerly of the University of California, has been appointed superintendent of the physical laboratory, and commenced work on January 1st. Dr. CHARLES E. ST. JOHN, formerly professor of physics and dean of Oberlin College, joined our staff in May. Mr. FERDINAND ELLERMAN has continued his work with the Snow telescope. Since the completion of the Pasadena laboratory, Dr. OLMSTED has carried on his spectroscopic work there. Miss LOUISE WARE, Miss JENNIE B. LASBY, Miss RUTH E. SMITH, and Miss CORA G. BURWELL have continued their study of photographs in the computing division. Miss LILLIAN M. WICKHAM joined the staff of the computing division on February 1st.

Professor ERNEST F. NICHOLS, Research Associate of the Carnegie Institution of Washington, has been engaged in an investigation of the absorption of the Sun's atmosphere and in laboratory investigations on Mount Wilson during the summer of 1908. Dr. WALTER M. MITCHELL, director of the Haverford College Observatory, and Mr. H. C. PLUMMER, of the Oxford University Observatory, have also spent some time on Mount Wilson, for the purpose of becoming familiar with the investigations in progress.

The work of the Smithsonian Expedition, carried on by Mr. ABBOT during the summers of 1905-06, was renewed on Mount Wilson in May and is still in progress. Mr. ABBOT is assisted in this work by Mr. LOUIS B. ALDRICH, of the University of Wisconsin. It is a satisfaction to state that arrangements have now been made by the Smithsonian Institution to construct a permanent station on the mountain, where studies of the solar constant and other investigations will be continued regularly in the future.

INVESTIGATIONS IN PROGRESS.

Direct Photography of the Sun.—Direct photographs of the Sun have been made daily, as heretofore, with the Snow telescope.

Work with the Spectroheliograph.—The total number of photographs of the Sun taken with the 5-foot spectroheliograph amounted, on September 30th, to 5,196. In March, through

the use of plates sensitized for the red by Wallace's process, it became possible to take photographs with the *Hα* line of hydrogen. These were found to differ in important respects from those obtained with *Hδ*. As it soon appeared that the *Hα* images gave a much more complete record of the hydrogen flocculi, mainly because of the great strength of this line in the upper chromosphere and prominences, where *Hδ* is weak, the former line was selected for the daily records, in place of *Hδ*. This change soon led to the discovery that sun-spots are surrounded by vortices, which occur in a region of the solar atmosphere higher than that recorded on *Hδ* plates. A full account of this work, illustrated with photographs of the vortices, may be found in No. 26 of the *Contributions from the Mount Wilson Solar Observatory*.

As the rapid changes in the vortices required that many photographs be made at short intervals, it became necessary to improve the performance of the Snow telescope and to modify the daily program of observations so as to include more *Hα* plates. As the result of experiment it was found that the reduction of the aperture of the cœlostat to 15 inches, while it only partially cured the rapid change of focal length caused by exposure of the mirrors to the Sun, almost completely eliminated such evidences of astigmatism as had seriously injured earlier photographs. For this reason all *Hα* exposures are now made with the 15-inch aperture. The early morning observations are devoted exclusively to the photography of the disk with the *Hα* line. In the late afternoon additional *Hα* plates of the disk are taken, together with one prominence plate (using *Hα* in place of H_2, the line formerly employed), one H_1 disk and one H_2 disk.

The remarkable sharpness of the best *Hα* plates, and the evidence they invariably afford of the existence of definite vortices and currents in the solar atmosphere, have led to many important developments in our work with the spectroheliograph. It now becomes feasible to undertake a systematic examination of sun-spot theories, and to pursue many investigations hitherto out of reach.

Miss WARE's measurements of the motions of 1,680 points in the calcium (H_2) flocculi, made with the heliomicrometer

on fifty-one negatives, taken with the 5-foot spectroheliograph during the period June 18th to September 22, 1906, have given the following results for the mean angular rotations (sidereal), corresponding to 5° zones (Table 1). The means in the table combine the results for corresponding latitudes in the northern and southern hemispheres, reduced from synodic to sidereal values.

Miss WARE has also measured the motions of 828 points in the hydrogen flocculi on thirty-five $H\delta$ plates (Table 1). The difficulties of identification are much greater than in the case of the calcium flocculi, since the hydrogen flocculi change more rapidly in form. It is thus necessary to use plates separated by an interval of only about twelve hours, whereas the same calcium flocculus may frequently be measured on plates separated by an interval of two or three days.

TABLE I.

Zone.	Calcium (H_2). No. of measures.	ξ	Hydrogen ($H\delta$). No. of measures.	ξ
0° ± 5°	232	14°.5	129	14°.3
± 5 ± 10	262	14 .3	105	14 .1
± 10 ± 15	317	14 .3	145	14 .4
± 15 ± 20	326	14 .2	120	14 .4
± 20 ± 25	259	14 .2	114	14 .5
± 25 ± 30	153	14 .0	95	14 .6
± 30 ± 35	99	13 .8	61	14 .8
± 35 ± 40	26	14 .0	43	14 .8
± 40 ± 45	6	13 .2	16	15 .2

It will be seen that while the motions of the calcium flocculi clearly show a decrease in angular velocity toward the poles of about the same magnitude as in the case of sun-spots, the hydrogen flocculi do not apear to follow the same law.

This work was near completion when the first $H\alpha$ photographs of the disk were obtained. The extensive whirls shown on these photographs indicate that the flocculi lying in the neighborhood of sun-spots, or within any region occupied by whirls, are unsuitable for the determination of the solar rotation. The $H\delta$ plates apparently represent the hydrogen in a lower region of the solar atmosphere, where the whirls are not clearly shown. Nevertheless, the motions of the $H\delta$ flocculi are probably affected by the whirls, which may account for

many peculiarities encountered in the measurement of the plates. It accordingly becomes necessary to study the rotation at the *Hα* level, by means of flocculi which are well outside of the whirls.

A further extension of the spectroheliograph work will soon be possible, as the 30-foot spectroheliograph, constructed in our instrument-shop during the year, is now nearly ready for trial.

Spectra of Sun-Spots.—Many photographs of spot spectra have been made during the year by Mr. ADAMS and myself. Most of these have been taken in the third order of the 30-foot spectrograph of the tower telescope and are greatly superior to the photographs made with the Snow telescope and 18-foot Littrow spectrograph. Double lines, which appear single in the previous photographs, are now clearly resolved, and a great number of additional faint lines, particularly those of flutings, are recorded. The preparation of a catalogue of the lines shown on the earlier plates was well advanced when the first of the new photographs was obtained. Their superiority has made it necessary to prepare a new catalogue, which will contain a much greater number of lines than the former one.

The hypothesis that the relative intensities of sun-spot lines are determined largely by a reduction in the temperature of the metallic vapors below that of the same vapors in the reversing layer is strongly supported by Dr. KING'S work with an electric furnace, described on another page of this report. Dr. OLMSTED'S detection of the red flutings of calcium hydride in spot spectra affords additional evidence in the same direction.

The discovery of the solar vortices suggested that the rapid revolution of electrically charged particles (assuming a preponderance of positive or negative ions, resulting from diffusion or other cause) should produce a magnetic field within sun-spots (Rowland effect). Photographs of spot spectra taken with the 30-foot spectrograph and the tower telescope showed a great number of close double lines, many of which had previously been seen visually by YOUNG and MITCHELL, who described them as "reversals." I accordingly examined the components of these lines and found their light to be circularly polarized in opposite directions. This is what would be observed if the vapors giving rise to these lines were seen

along the lines of force of a strong magnetic field. Other spot lines, which are widened but not doubled, were found to be shifted in position when the nicol was rotated. Spot vortices rotating in opposite directions give doublets having components in which the direction of the circular polarization is reversed. Triplets, the central line of which is plane polarized, also occur in spot spectra. These and similar results, confirmed by many laboratory tests, conclusively prove that a powerful magnetic field (2,800 to 4,500 gausses) exists in sun-spots.

Photographic Comparison of the Spectra of the Center and Limb of the Sun.—The completion of the tower telescope, and the much more powerful spectrographic apparatus available with this instrument, led to the transfer of the spectroscopic work on various parts of the Sun's disk from the Snow telescope to the tower. The considerably greater dispersion available has proved to be of particular value in connection with Mr. ADAMS'S study of the spectra of the center and limb of the Sun; the quantities measured being so minute as to require the greatest linear scale which it is possible to obtain. In order to secure the two spectra simultaneously, and thus avoid possible errors arising from change of temperature or unequal illumination of the grating in the two positions of the Sun's image on the slit, a special attachment has been constructed for the purpose. Two small diagonal prisms throw light from the edge of the Sun upon the slit, while the light from the center passes unobstructed on either side of the central prism. Photographs taken with this apparatus have proved extremely satisfactory and thoroughly reliable as regards the absolute displacements involved. At the present time negatives are being taken for the purpose of providing a photographic map of the spectra of these two portions of the Sun's disk, and it is expected that this map will be completed some time during the winter.

In addition to the conclusions drawn from the measurement of the displacements referred to in the last report, the important result has been found that the spark or "enhanced" lines in the spectrum seem to show greater displacements at the limb of the Sun than do the majority of the other lines.

This has a vital bearing on the question of the level at which these lines originate in the Sun's atmosphere. It will require, for satisfactory explanation, a series of laboratory investigations on the displacements of spark lines under pressure.

Spectrographic Investigation of the Solar Rotation.—Mr. ADAMS's photographic investigation of the rotation of the Sun, by means of the displacements of the spectrum lines at the opposite limbs, has been continued throughout the year with the powerful spectrograph of the tower telescope. The advantages of this instrument over the 18-foot spectrograph of the Snow telescope, with which the investigation of 1906 to 1907 was carried on, are very considerable. In addition to the superior quality of the solar image, and greater freedom from astigmatism and change of focus, the larger linear scale furnished by the instrument, and the possibility of setting for different position angles, by rotation about a vertical axis, have proved of great value. The plates employed in the study of the rotation from lines in the violet part of the spectrum have all been taken in the third order of the grating. Plates including the region about $H\alpha$ in the red part of the spectrum have been taken in the second order.

About twenty-five plates covering the same region of the spectrum that was employed in the investigation of last year have been measured and reduced. The degree of accuracy obtained seems to be appreciably higher than that secured with the plates from the 18-foot spectrograph. The comparison of the results of the two series of observations indicates very close agreement in the latitudes running from 0° to 45°. From 60° to the pole, however, the values obtained from the present series fall appreciably below those of last year, the difference amounting to about 0.04^{km} at a maximum. It does not at present seem probable that this difference is to be ascribed to a real variation in the rotation of the Sun, since it is not shared in by the zones of lower latitude, in which the activity of the Sun, as indicated by the presence of spots and flocculi, is much greater. A more probable explanation would seem to be that it is due to errors arising in the former series of observations, from astigmatism and other defects of the solar image. The values obtained from the present year's series of observations are now being collected and will be published within a short time.

One of the most important contributions furnished by the investigation of the rotation of the Sun is Mr. ADAMS's discovery that the hydrogen gas producing the α line of hydrogen moves with a decidedly greater angular velocity than the general reversing layer, and seems to be subject to quite a different law from that of the ordinary equatorial acceleration. The first indications that a result of this kind was to be expected were furnished by the study of photographs of the spectra of the center and limb of the Sun, and as soon as these became evident the investigation was continued with the regular rotation apparatus of the tower telescope. The results obtained from the earlier plates of the series are given in Table 2:—

TABLE 2.

	v km	$v+v_1$ km	ξ	Period days
—0°.1	2.07	2.21	15°.7	22.9
9 .3	2.01	2.15	15 .5	23.2
14 .8	1.96	2.10	15 .4	23.4
22 .7	1.90	2.03	15 .6	23.1
29 .7	1.73	1.87	15 .3	23.5
44 .5	1.44	1.55	15 .4	23.4
59 .3	1.04	1.12	15 .6	23.1
73 .5	0.63	0.67	16 .7	21.6

The inclusion of a larger number of results will probably indicate a slight decrease in the value of the angular velocity toward the pole of the Sun, but the law will evidently be very different from that of the reversing layer. It also seems probable that the value of the angular velocity at the equator will be somewhat reduced when a larger series of observations is available.

Some recent work on the blue line of calcium at λ 4227 indicates that the rate of rotation given by this line differs from that of the general reversing layer. A series of photographs obtained especially for the study of this line is now being investigated.

Absorption and Scattering in the Solar Atmosphere.—Professor E. F. NICHOLS, Professor of Physics in Columbia University and Research Associate of the Carnegie Institution of Washington, has just completed an important investigation on Mount Wilson. The object of the work is to determine the

law of absorption and scattering of light in the solar atmosphere. An image of the Sun, formed by the Snow telescope, falls upon a slit. The rays which enter the slit are rendered parallel by a collimating mirror, pass through a large prism, and the spectrum thus formed is brought to a focus by a second mirror. A bolometer, kindly supplied by Mr. ABBOT, is set at a certain wave-length. As the sun's image transits across the slit, the deflections of the galvanometer are recorded on a moving photographic plate. In this way photographed curves, corresponding to a number of different wave-lengths, give a measure of the solar radiation at points along a diameter parallel to the direction of the diurnal motion. Several refinements of the method, which are due to Professor Nichols, should lead to results of high precision. The observations have been completed and will be reduced as soon as possible.

PHYSICAL LABORATORY.

To meet the needs of experimental work, which require the use of electric currents much stronger than can be economically generated on Mount Wilson, the construction of a new physical laboratory, on land adjoining our Pasadena instrument-shop, was begun in the autumn of 1907. On January 1, 1908, the work had progressed as far as the completion of the exterior walls and roof and the excavation of the 30-foot pit in the middle of the floor. During January and February the interior arrangements were for the most part completed, including the cementing and drying of the pit, the laying of the cement floor with conduits for electric wires embedded in the cement, the construction of concrete piers for the apparatus, the installation of the electrical machinery, and the fitting up of the chemical laboratory and dark-room. About March 1st actual investigation work began with the mounting of the 30-foot spectrograph in the pit and the setting up of the large electric furnace, the construction of which had been completed in the machine shop after being received from the maker. A description of the laboratory may be found in *Contributions from the Mount Wilson Solar Observatory,* No. 27.

The electric furnace quickly yielded results which demonstrated its superiority for spectroscopic work over any existing

apparatus of the kind. The work so far carried on by Dr. KING has included a study of the spectra of iron, chromium, titanium, and vanadium, as given by the furnace in vacuum at different temperatures. The effect of temperature and different amounts of vapor upon the principal lines of calcium was also observed. A series of measurements were made with an optical pyrometer to obtain the temperatures at which the various spectra were produced. Temperatures as high as 3,000° C. were measured. The spectra show almost as many lines as are given by the electric arc; while the effects of different temperatures in changing the relative intensity of lines are of high interest when considered in connection with both astronomical and physical problems. The effect of different gases in the furnace, also of high pressures and the observation of absorption phenomena, offer each a large field of work which has not yet been taken up.

During April an electric furnace of the Moissan type, inclosed in an air-tight chamber, was set up and has been used by Dr. OLMSTED for the investigation of the spectra of hydrides, to be used for comparison with solar spectra in the identification of unknown lines, especially of the flutings obtained in the spectra of sun-spots. Good results for the spectra of magnesium and calcium hydrides are being obtained.

The recent discovery of the separation of lines in sun-spots, indicating the presence of magnetic fields on the Sun, has led to a supplementary laboratory investigation of the Zeeman effect, the large Du Bois electro-magnet being arranged so that an electric spark between the poles may be photographed either parallel to the lines of magnetic force or at an angle to them. The magnet gives a field strength up to 36,000 c. g. s. units. Photographs are being obtained of the spectra of iron and other substances, giving an excellent separation of the spectrum lines for magnetic fields of known strength, allowing a detailed comparison with the separations obtained in the solar photographs.

Most of the laboratory investigations cover the whole range of the visible spectrum, requiring the use of photographic plates sensitive to red light in addition to those commercially obtainable. The laboratory dark-room is fitted up for the

sensitizing of plates for the red region, which are thus used while perfectly fresh and are handled with the same facility as the ordinary plates.

The comparison of intensities of lines on photographic plates has been carried on by Miss WICKHAM of the computing division through the use of the Zeiss spectrocomparator, adapted so as to show a portion of the spectrum under examination and a specially prepared photographic scale in the field of view at the same time, giving a definite value to the intensity of each spectrum line and allowing an accurate comparison of the intensities of lines in different spectra.

COMPUTING DIVISION.

Some of the results obtained in the computing division, under the direction of Mr. ADAMS, have already been given. The heliomicrometer has been used by Miss WARE for all measurements of the positions of flocculi. The rapidity of measurement has been greatly increased by ruling one hemisphere of the globe with meridians and parallels 1° apart. The position of the cross-hairs, after they have been set on a flocculus, is estimated to tenths of a degree. The precision of measurement proves to be amply sufficient; in fact, the latitudes and longitudes are almost as precise as those obtained with the aid of the circles.

The measurement of the areas covered by the calcium flocculi, to serve as an index of the solar activity, has been continued throughout the year. This work has been carried on by Miss SMITH with the aid of the special photometer devised for this purpose and referred to in the report of last year. The method of reduction which has been followed is the same as that previously described and the results obtained have proved to be fully as satisfactory as the character of the objects measured would seem to warrant. The values obtained for a period of about seven months have been platted and indicate very clearly the variation in the areas covered by the flocculi as the spot-groups pass across the surface of the Sun. The time interval is of course too short to give any indication of the eleven-year period, but there is every reason to suppose that these determinations will furnish an excellent measure of the Sun's activity.

The measurement of the plates used in the determination of the rotation of the Sun has been done for the most part by Miss LASBY, and in addition she has devoted considerable time to the measurement of the displacements found in the spectra of the center and limb of the Sun. The extension of the rotation work to include the lines of hydrogen and the line of calcium at λ 4227 has increased considerably the amount of measurement which it has been necessary to do in carrying out this research.

The definitive reduction of our plates of the sun-spot spectrum, and the identification of the unknown lines which appear on them, has involved a great amount of measurement and reduction. This work has been carried on for the most part by Miss BURWELL and Miss WICKHAM. Miss BURWELL has determined the wave-lengths of the sun-spot lines, and Miss WICKHAM has measured, for purposes of identification, plates of the titanium-oxide flutings obtained in the laboratory. Some idea of the amount of labor involved may be obtained from the fact that in the extent of spectrum between λ 5000 and λ 5500 there occur over 1,500 lines, whose wave-lengths in the spot spectrum must be determined and for which suitable identifications with laboratory spectra have to be found.

In addition to her work on the measurement of the titanium-oxide flutings, Miss WICKHAM has devoted much time to the estimation of the intensities of the lines upon the plates of furnace spectra obtained by Dr. KING.

CONSTRUCTION DIVISION.

The construction division, under the superintendence of Professor RITCHEY, has been occupied during the year with the erection on Mount Wilson of the steel building and dome for the 60-inch reflector; the completion of this instrument, its transportation to the mountain and its erection in the dome; the erection and equipment of the new spectroscopic laboratory in Pasadena; the construction of a spectroheliograph of thirty feet focal length and a grinding-machine for the 100-inch Hooker mirror; the completion of the Mount Wilson road; and other miscellaneous work.

The instrument and optical shops were closely occupied with the 60-inch reflector during the entire year. The optical work included the grinding and figuring of the two plane and two hyperboloidal mirrors, which were tested in combination with the 60-inch mirror. In the instrument shop the mounting was completed and erected, so that the operation of all parts of the mechanism could be thoroughly tested before they were sent to the mountain. In the tests the various quick and slow motions, effected by electric motors, worked perfectly, and the mounting showed no evidence of flexure.

The experience of the previous year had shown the necessity of widening some sections of the Mount Wilson road, in order to permit the large and heavy parts of the mounting to be carried safely on the automobile truck. This work was done in the spring, immediately after the close of the rainy season. At the same time the erection of the steel building and dome was resumed. During June and July the mounting was taken to the summit without difficulty on the truck, though four strong mules were needed to assist the engine in hauling the heaviest loads, weighing five tons, over the steep grades. The most troublesome load was the large steel telescope-tube, 6.5 feet in diameter and 18 feet long, which was taken up as a single piece. All parts of the telescope, including the 60-inch mirror, reached the summit without the slightest injury. Work on the dome and building was completed early in September, and the telescope was ready for use in December. It is now yielding excellent photographs of nebulæ and other objects.

A spectroheliograph of thirty feet focal length, designed for use with the tower telescope, has been completed and is now in use. The great linear dispersion of this instrument, and the fact that it will permit three photographs of the same region of the Sun to be taken simultaneously with the light of three different lines, should prove advantageous in certain new fields of solar research. The dispersing member of this spectroheliograph is a large fluid prism, with circular faces twelve inches in diameter, which is twice traversed by the light (Littrow arrangement).

A 100-inch disk for the Hooker telescope mirror has been received from the St. Gobain plate-glass works, but it is not sufficiently homogeneous, and another one will be cast.

GEORGE E. HALE, *Director.*

STUDENTS' OBSERVATORY, BERKELEY ASTRONOMICAL DEPARTMENT, UNIVERSITY OF CALIFORNIA.

The work of the Berkeley Astronomical Department during the last year has been confined almost entirely to instruction. The enrollment for the year exceeds the five hundred mark. No additions have been made to the teaching force. Several courses that are usually given could not be given this year, due to the absence of the Director, Professor A. O. LEUSCHNER, who has been abroad since July on his sabbatical leave. Because of his absence no work has been done upon the Watson asteroids.

A short but excellent series of photographs of Comet Morehouse was obtained in October by Mr. MEYER. The orbit of this comet was computed by Messrs. EINARSSON and MEYER.

The Acting Director, assisted by Mr. MEYER, computed the orbit of *Jupiter's* VIII Satellite by LEUSCHNER'S method.

A few micrometer observations of Comet Morehouse have been made. The regular seismological and meteorological observations have been continued during the year. The orbits of Comet Morehouse and *Jupiter's* VIII Satellite have been published in the *Lick Observatory Bulletin.*

A few additions have been made to the equipment of the observatory, among which are: 1. A new position micrometer for the 6-inch telescope, made by GAERTNER of Chicago (the old micrometer has been adapted for use on the 5-inch telescope; 2. A small spectrometer for student use; 3. An induction coil; 4. A storage battery.

In September Director LEUSCHNER attended the Versammlung der Astronomischen Gesellschaft at Vienna, when he presented an outline of his new analytical method for determining the orbits of new satellites. His paper is entitled "Versuch einer Bahnbestimmung mit sofortiger Berücksichtigung der Störungen." It has been published in the *Vierteljahrsschrift der Astronomischen Gesellschaft.*

R. T. CRAWFORD, *Acting Director.*